ELECTROMAGNETIC FIELD STRUCTURE AND IMPEDANCES OF CCP HF DISCHARGE WITH LARGE ELECTRODES

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The high-frequency CCP low pressure (ν << ω) discharge of with large electrodes (radius 22.5 cm), excited by 100 MHz electromagnetic field, is considered. This type of discharge is supported by surface waves propagating along the plasma –space-charge sheath – metal electrode interface [1]. The sheath is a region, depleted by electrons, produced as a result of the lack of thermodynamic equilibrium between the plasma and the wall. The analytical expressions for the dispersion characteristics of the surface waves are considered in [2].

Due to having two boundaries, two surface waves are existing in the discharge. If both sheaths have the same thickness, wave electromagnetic field distribution will be even for one wave and odd for the second one. The calculation shows that the length of the odd surface wave is much less than the length of even wave. Therefore, spatial resonance for this wave can be observed at smaller radii of the electrodes. In this case, the amplitude the odd wave can exceed the amplitude of the even wave, even at low- symmetry violation of discharge excitation system.

Recently, however, the asymmetry of excitation has been used to create additional high-frequency field in the peripheral region of the plasma, which allows to align the spatial distribution of the electron density along the electrode [3]. Discharge characteristics with low asymmetry of excitation under the assumption that the sheath thicknesses were equivalent it considered in [4]. The present work is continuation of [4]. In actual reactor conditions, especially at multifrequency case sheathes near electrodes have different sizes. In this paper, characteristics of surface waves in such asymmetric system are calculated. In this case, the surface waves cannot be divided into even and odd wave and even for symmetrical HF matching circuit both waves are excited. The interference of these waves can lead to ionization inhomogeneities in the space between the electrodes and the disruption of plasma uniformity.

Discharge impedances, taking into account no symmetry of system and excitation of both surface wave is calculated. The model equivalent circuit for discharge is proposed. The circuit allows finding the amplitude of each surface wave, and the RF currents on the sidewall of the discharge chamber. The obtained results allow to determine the conditions for optimal discharge excitation for the obtaining the uniform plasma with a high density of electrons.

References

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